Reproduce with whom?

Emergence of reproductive isolation in ecological speciation

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Reproductive strategies from genes to societies
Debrecen, 2019

Outline

Why speciate?

- Darwin:
  - Speciation is driven by the advantage of being different.
  - No clue on reproductive isolation.
- Allopatric (Mayr) speciation:
  - No way for divergent evolution in a panmictic population.
  - Populations must be geographically separated first!
- Ecological (competitive, adaptive, etc.) speciation:
  - Reproductive isolation is a consequence of divergent selection.
  - Parsimony: ecological possibility for diversification drives diversification.

Mallet: Mayrs view of Darwin: was Darwin wrong about speciation? (2008)

Nosil: Ecological Speciation. (2012)

Questions

Why adaptation leads to reproductive isolation?

How does emergence of reproductive isolation is affected by spatial structure?

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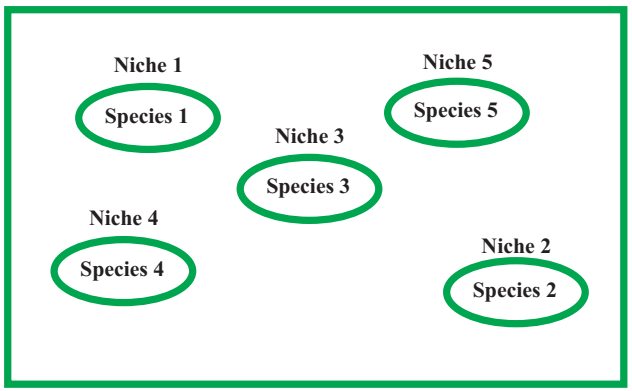
How does emergence of reproductive isolation is affected by spatial structure?

Why are there so many kinds of animals?

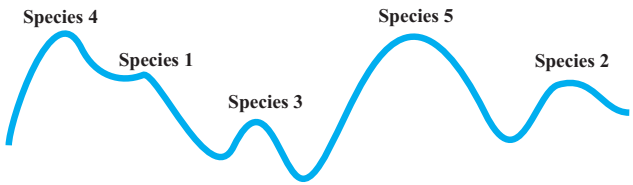
Background: different pictures in ecology and evolution:

Niche space



Species occupy different *niches*.

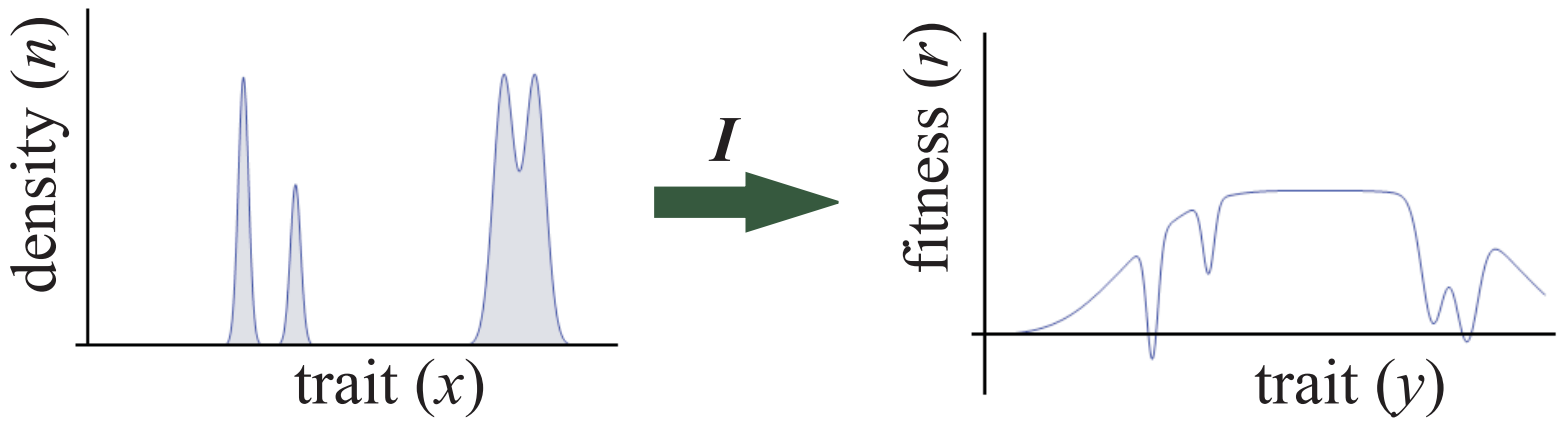
Adaptive landscape



Species occupy different *peaks of landscape*.

Conceptual clarification is needed!

Regulated landscape



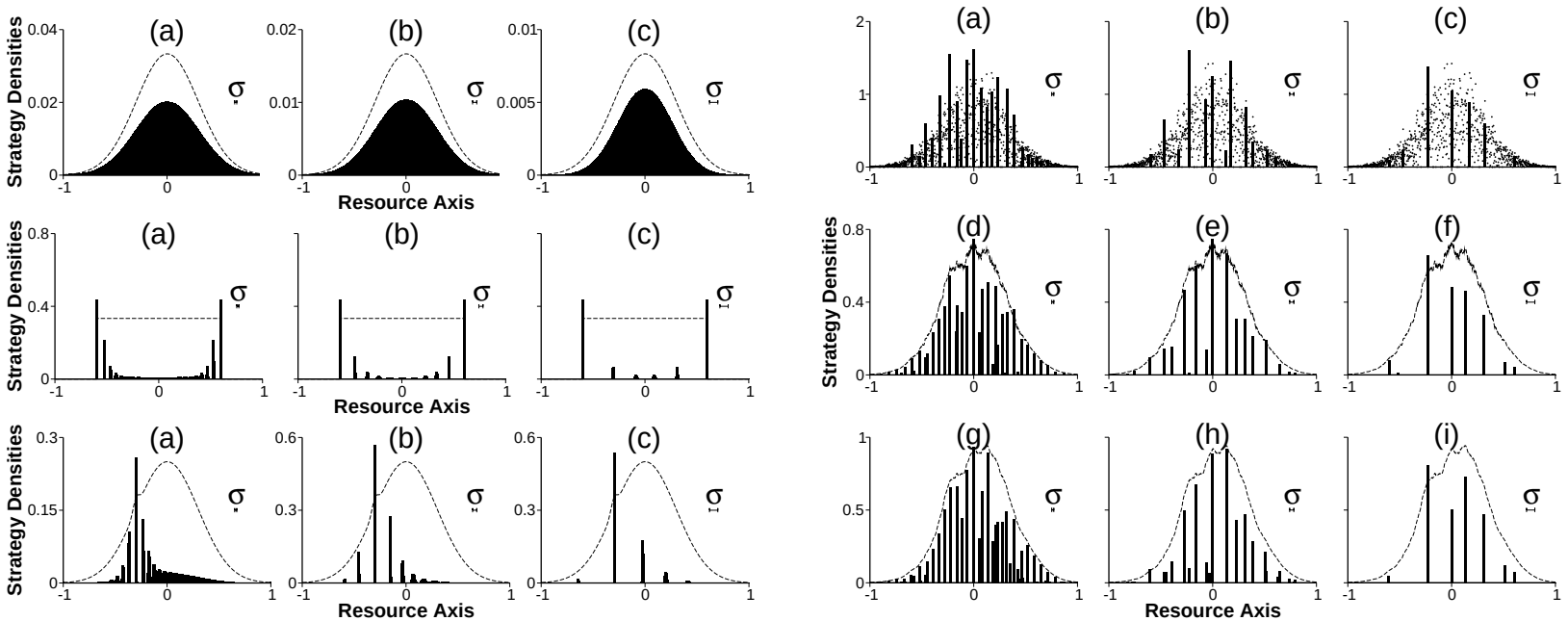
Competition: I eat your food and therefore reduce your fitness.

Competition and evolution to avoid competition are meaningless on a landscape which do not take into account the biotic feedback.

Meszéna (2005); Meszéna, Gyllenberg, Jacobs & Metz et al. (2005)

Is there a limit for similarity?

Lotka-Volterra competition *a la* MacArthur & Levins (1967)
Gaussian carrying capacity & competition kernel.

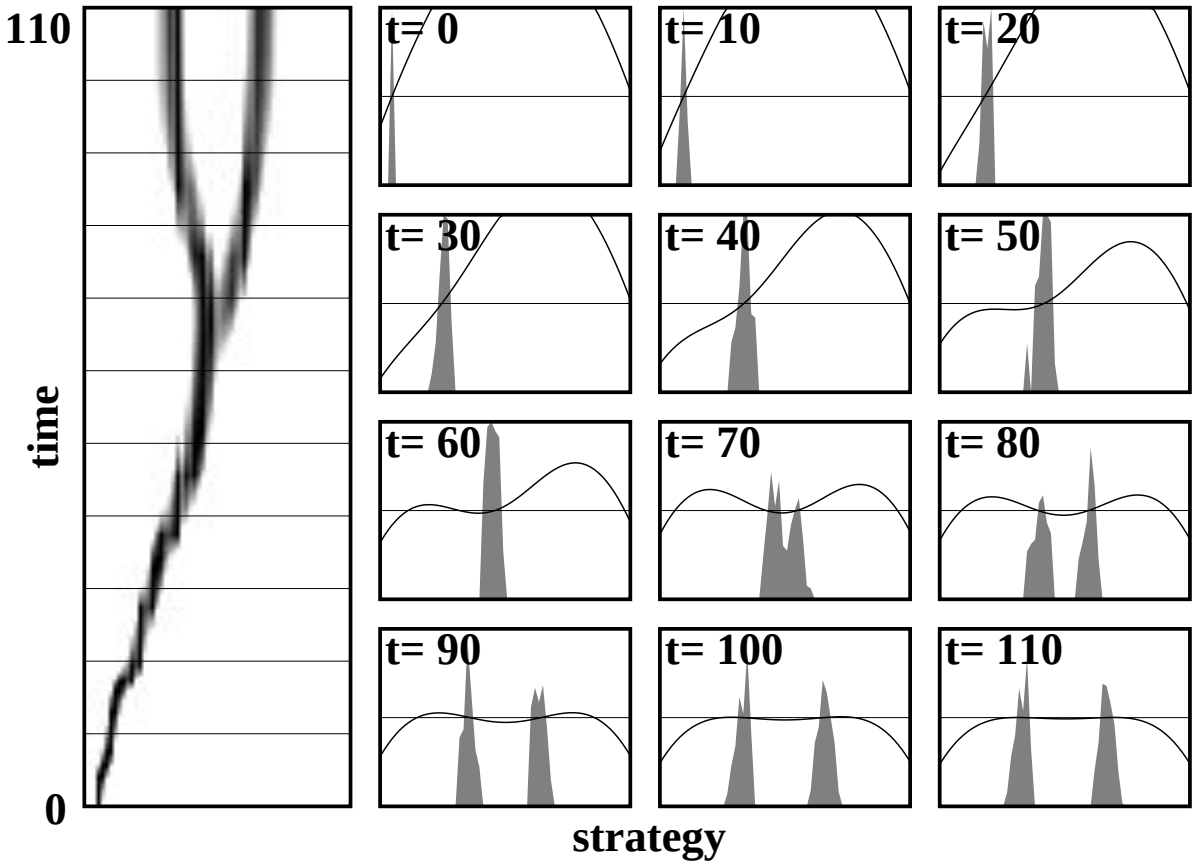


Except the immediate vicinity of continuous coexistence:
Discretization! Segregation by niche width!

Gyllenberg & Meszéna (2005); Szabó & Meszéna (2006)

Evolutionary branching for clonal organism

MacArthur & Levins ecology + mutation; clonal inheritance



Branching, i.e. evolutionary discretization!

Gertitz, Metz, Kisd &, Meszéna, (1997)

Speciation with multilocus genetics

Modified fronm Dieckmann & Doebeli (1999)

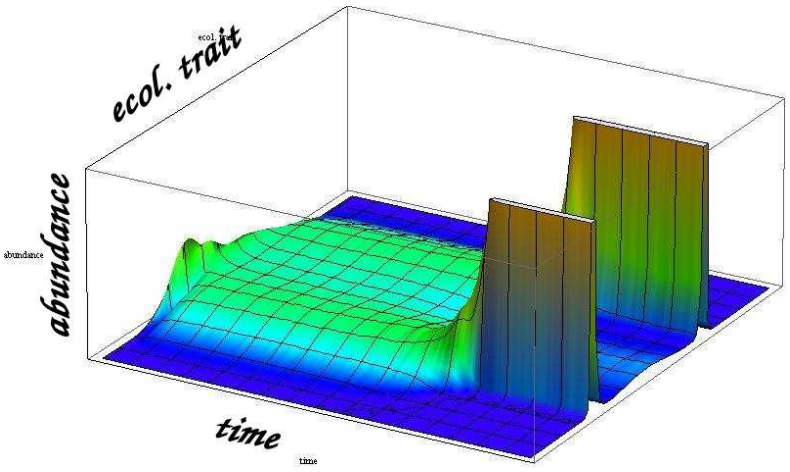
Ecology: MacArthur-Levins (1967)
Multilocus traits:

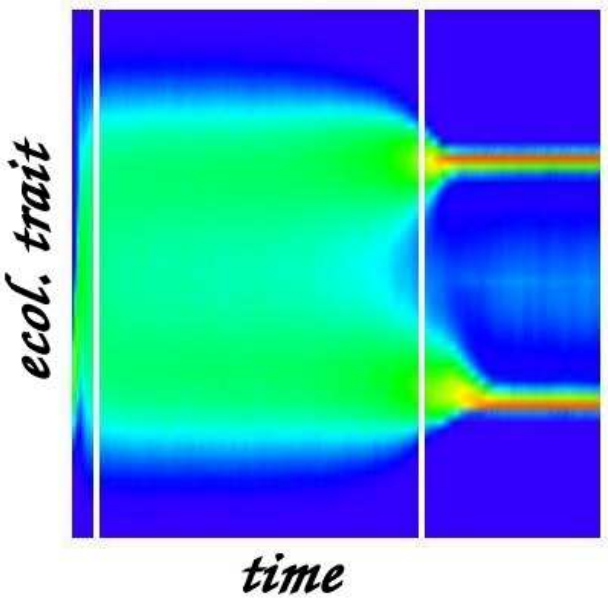
- Ecological trait: 2 x 32 loci
- Mating trait: 2 x 16 loci

Two allels per locus (0, or 1), additive, random recombination.
Assortative mating according to the ecological trait.

Meszéna & Dieckmann: Three-phase transitions to reproductive isolation (2019)

Three phase speciation process

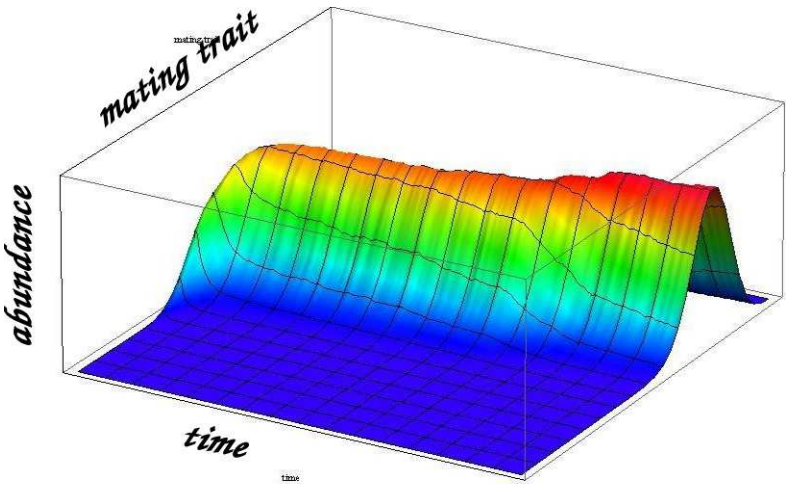


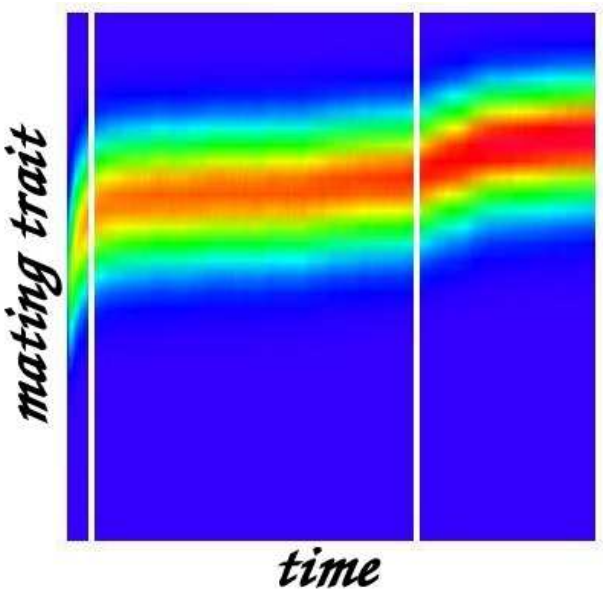


Three phases

- First: fast to the middle, widened trait distribution
- Second: slow, gradual transition to bimodality
- Third: fast completion of segregation

Three-pase speciation: Mating trait

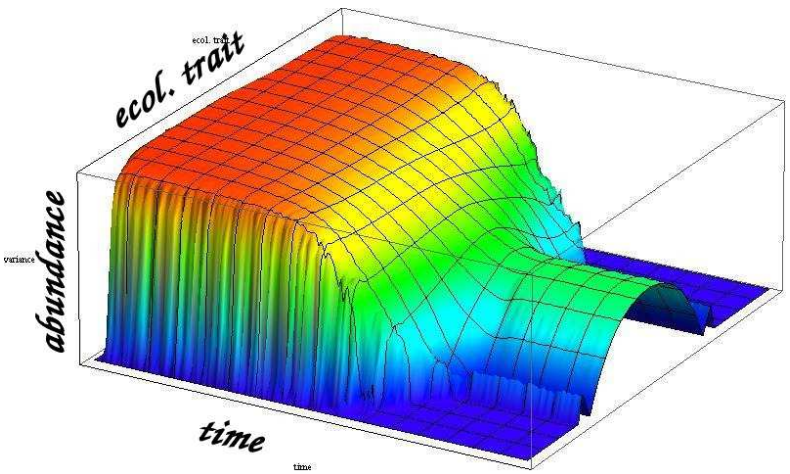


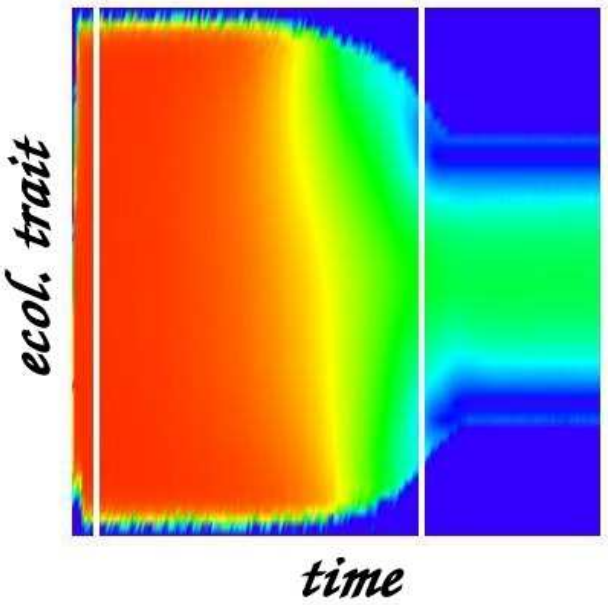


Three phases

- First: fast increase of assortativity
- Second: minimal additional change
- Third: fast further increase of assortativity

Three-pase speciation: Additive variance

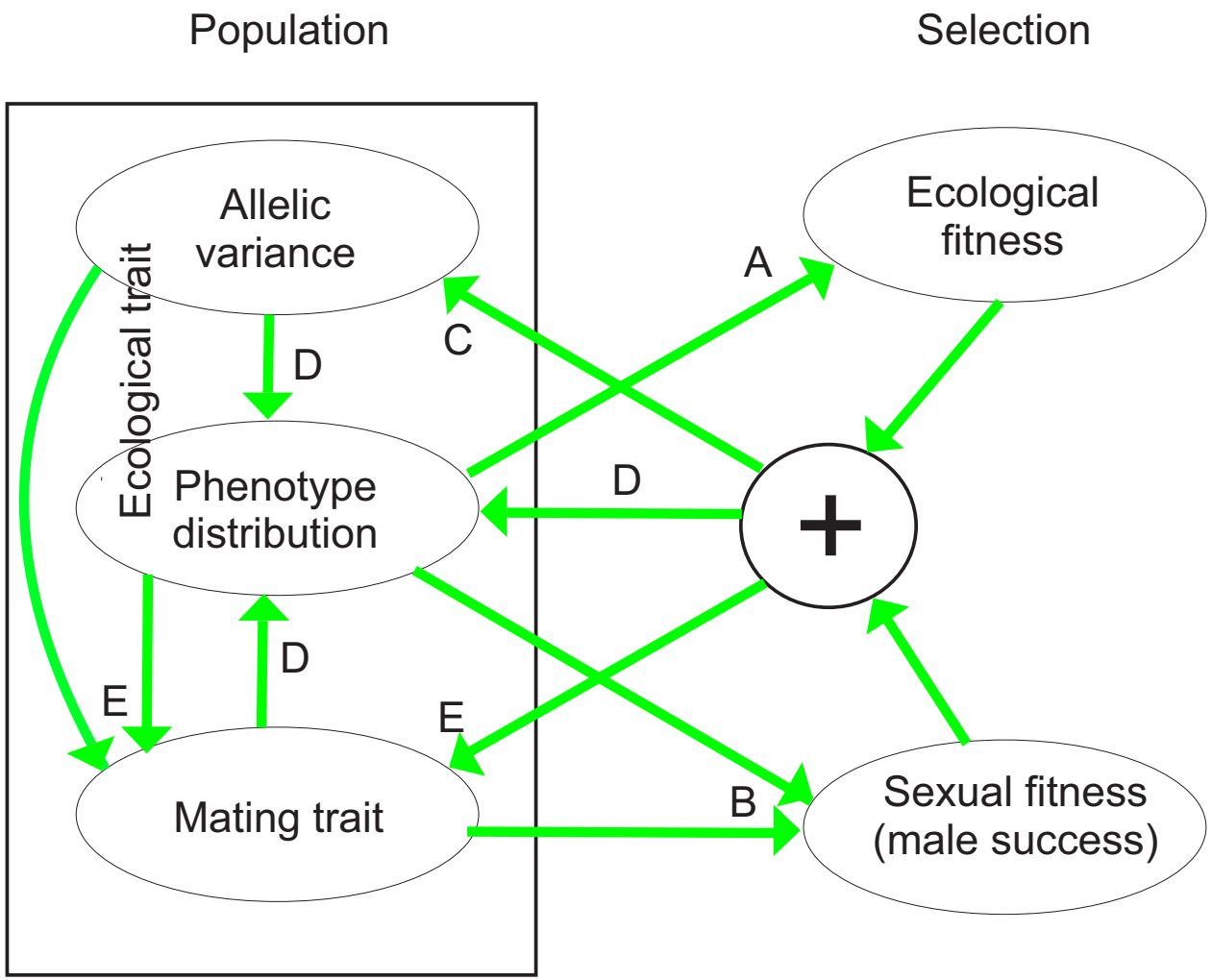




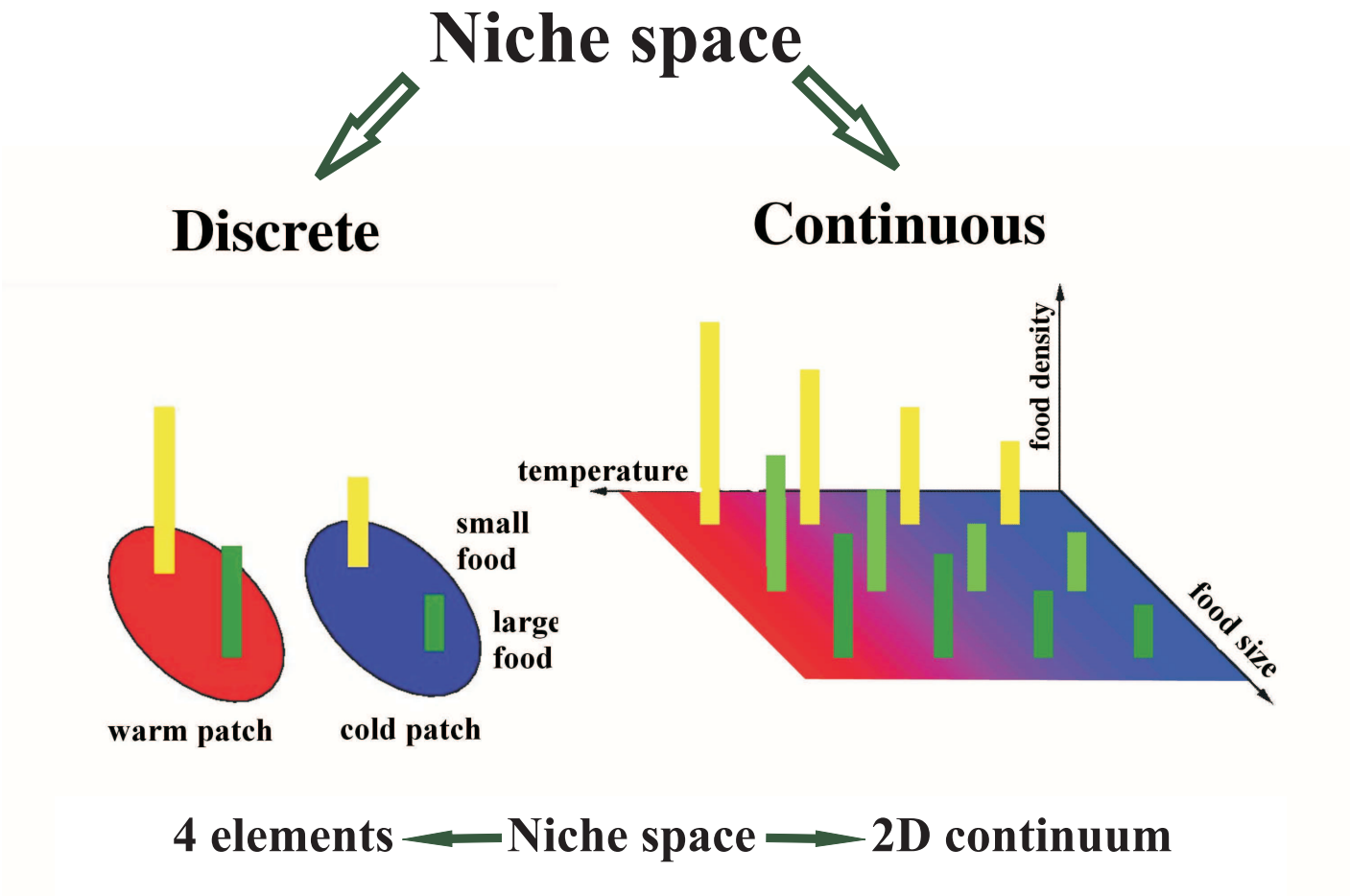
Three phases

- First: no significant change of variance
- Second: accelerating loss of genetic variance
- Third: seems to be initiated by the loss of genetic variance

Feedback structure

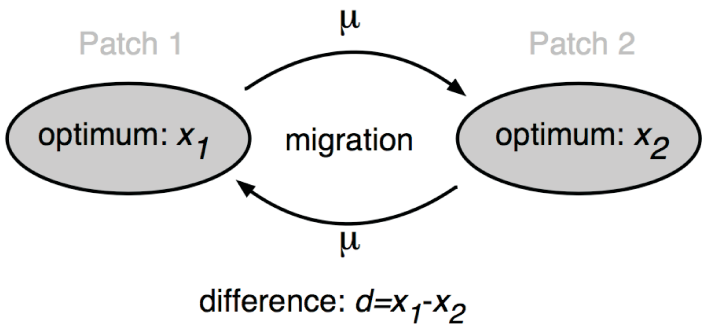


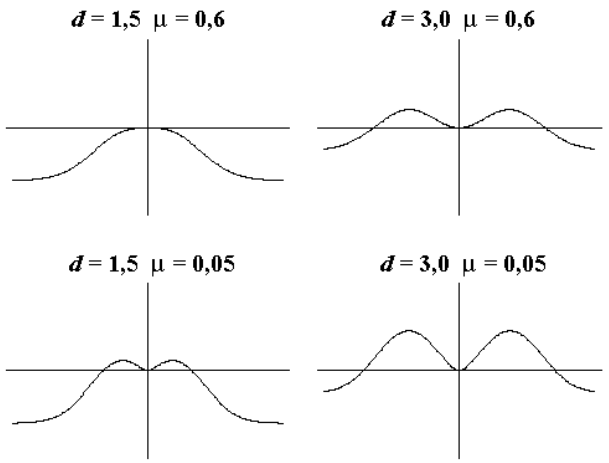
Ecology of spatial structure: Ways of niche segregation

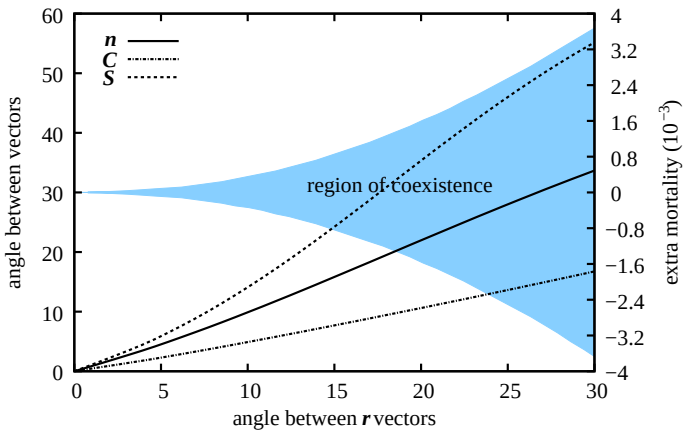


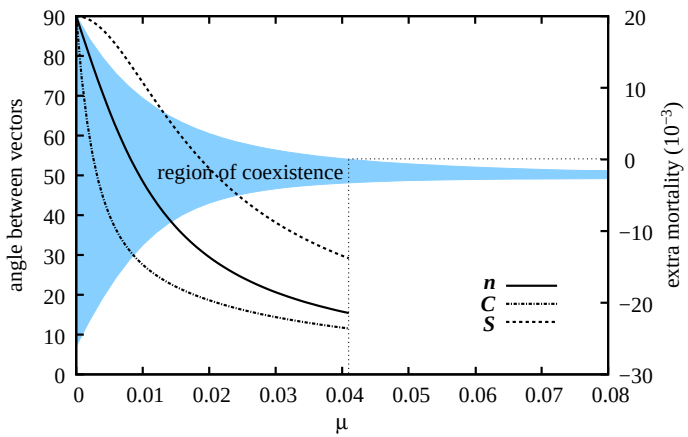
Parallelism between resource and habitat segregation!

Fitness and coexistence in a two-patch environment







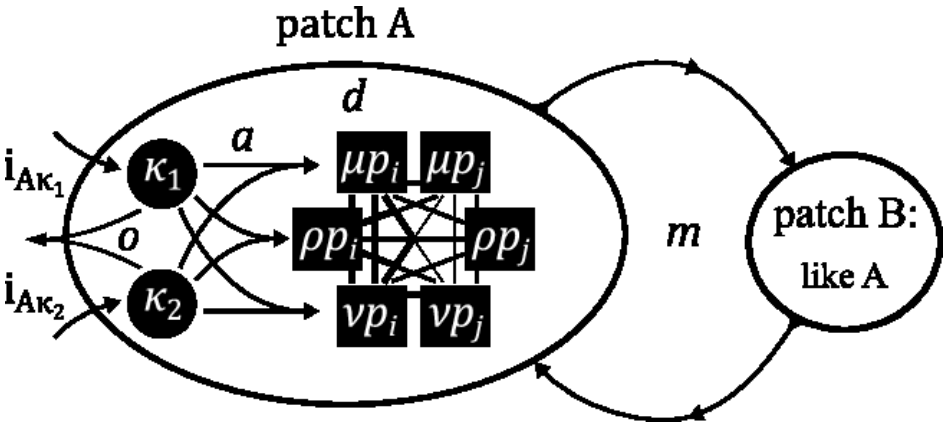


Fitness and coexistence on the large spatial scale!

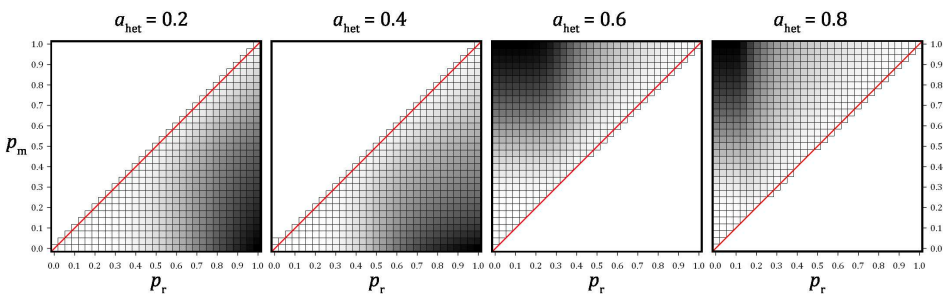
Meszéna, Czibula & Geritz (1997); Szilágyi & Meszéna (2009)

Reproductive isolation in a two patch, two resource model

Model setup



Pure resource segregation:

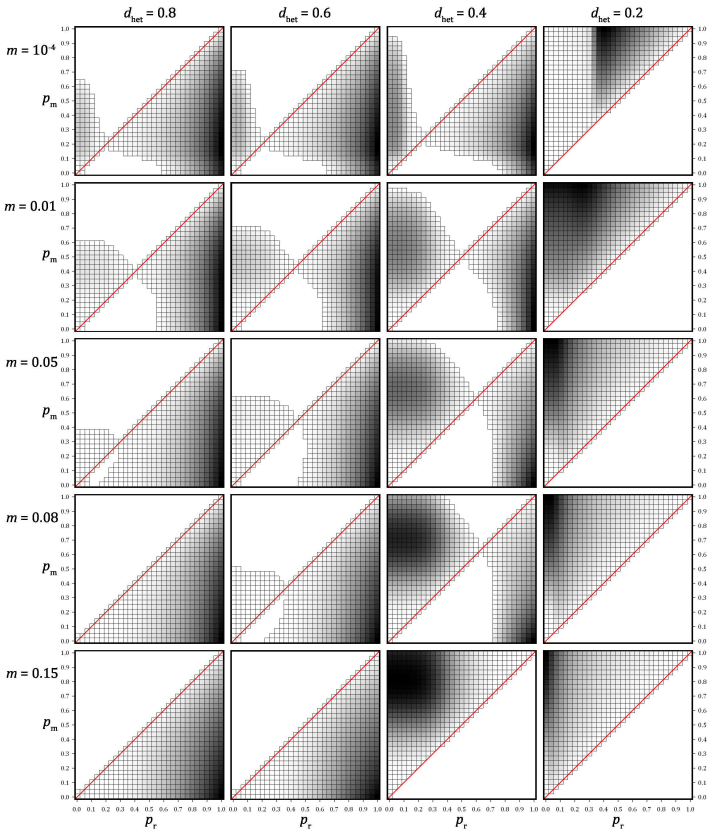


Disadvatage of ecological heterozygote selects for assortativity!

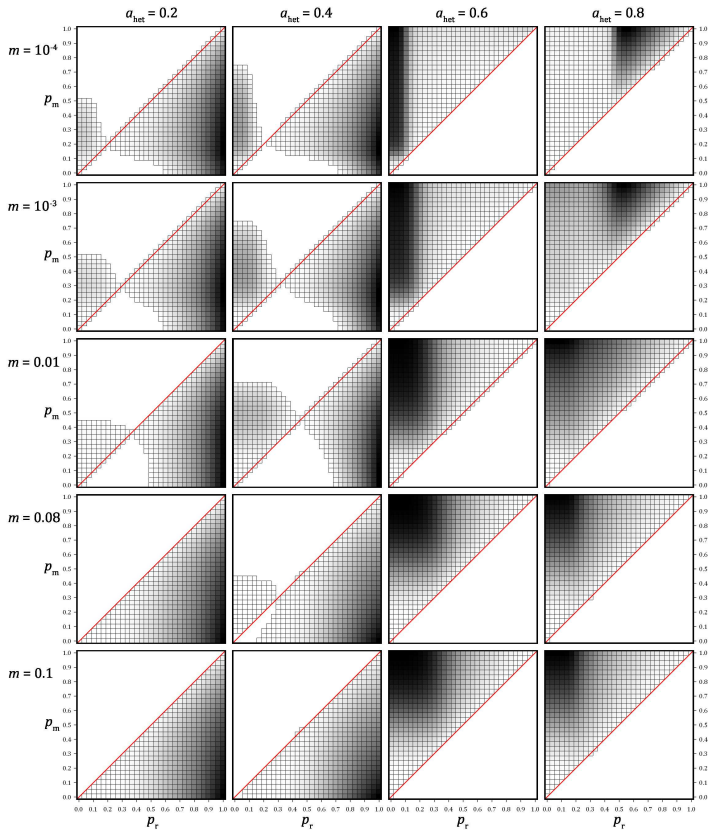
Spatial segregation

Patches differ in

environmental condition



resource distribution



Decreased migration rate modifies evolution!

Conclusion

Why adaptation leads to reproductive isolation?

- Essence of speciation is *not* the accidentally arising incompatibilities.
- Reproductive isolation is essentially an adaptation to a multi-niche environment. (Accidents may help.)

How does emergence of reproductive isolation is affected by spatial structure?

- Speciation is rarely expected to be strictly sympatric.
- Spatial heterogeneity may help to initiate evolution for assorativity, but may inhibit reaching complete reproductive isolation.

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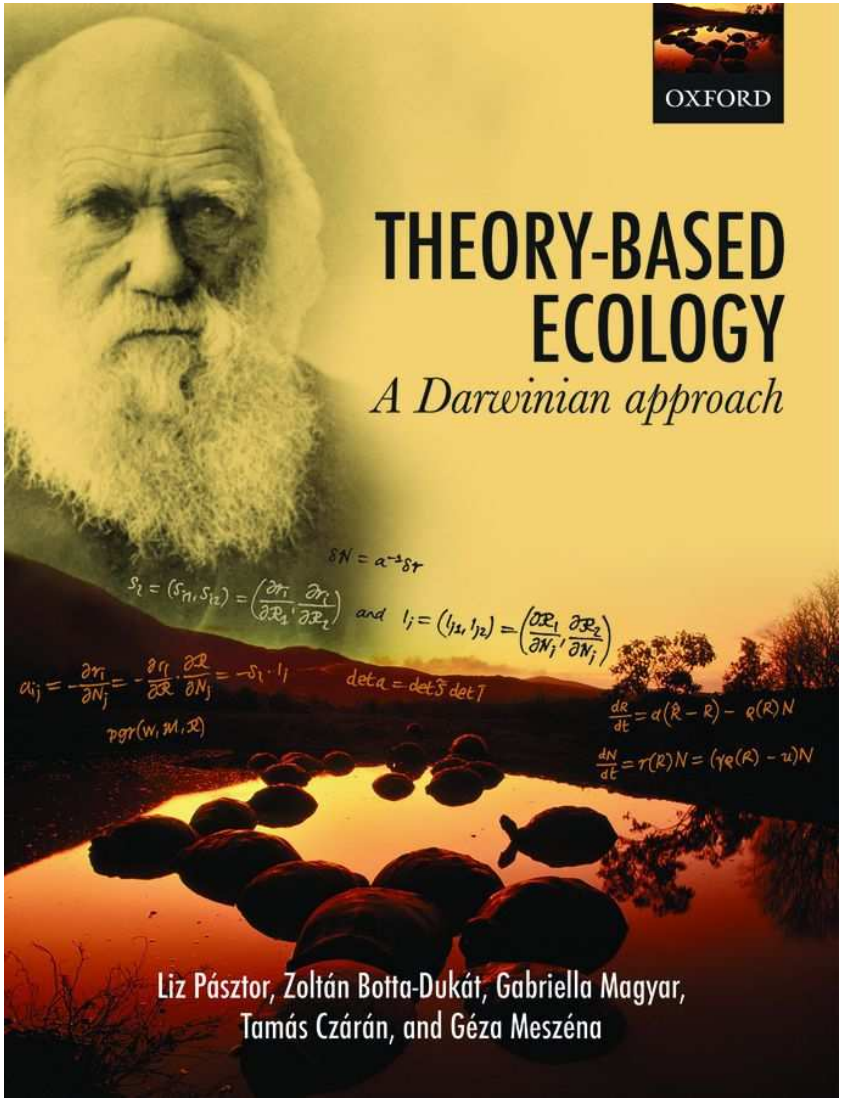
Theory-Based Ecology: A Darwinian approach



Is there such thing, as theory-based ecology?

At least, we have a book on it...

Enjoy!!!

Thanks

Theory Based Ecology

- Liz Pásztor
- Zoltán Botta-Dukát
- Tamás Czárán
- Gabriella Magyar

Adaptive Dynamics

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- Éva Kisdi

(Former) students

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- Gyuri Barabás
- Benjamin Márkus

- Stefan Geritz
- Ulf Dieckmann

Thanks for your attention!